Some Luminous Fishes of the Genera *Yarrella* and *Polyipnus*

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FISHES OF THE GENUS *Polyipnus*, in the family Sternoptychiidae, and of the genus *Yarrella*, in the family Gonostomatidae, like some other deep-sea luminous fishes, are furnished with numerous luminous organs, which usually may be seen on the ventral surface of the body.

Yarrella (Goode and Bean) is a comparatively new genus, in some respects intermediate between the genera *Gonostoma* and *Porichthys*, and is so called in honor of the ichthyologist, William Yarrell, F.L.S. (1789–1856).

In Japan two species of this genus—*Yarrella blackfordi illustrius* McCulloch and *Yarrella blackfordi elongata* subsp. nov.—were reported by Matsubara (1938).

The type of the genus *Polyipnus* is *P. spinosus* Günther, which was obtained by the vessel "Challenger," between the Philippine Islands and Borneo, at a depth of 250 fathoms.

Many species of these two genera have been examined and described. The structure of their luminous organs has been known for some time, but little or no work has been done on the luminous phenomenon of these organs.

I have collected specimens of these fishes in Japan, in the bays of Tosa and Sagami, since 1935 and, with this living material, have been able to observe the phenomenon of their luminescence in the dark, to examine the structure of their luminous organs, and especially to determine whether or not the luminescence is due to luminous bacteria.

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The two species upon which I report here are *Polyipnus stereope* Jordan and Starks and *Yarrella blackfordi illustrius* McCulloch. Usually most of these fishes are taken in deep water by trawlers, but occasionally they come up to the surface during the night. It was on such an occasion that I caught *Polyipnus stereope* near the coast of Suzukawa, in the Prefecture of Shizuoka, by means of the Zibiki-Ami (the Japanese name for a large seine net). This procedure enabled me to study this fish alive, in the dark.

I have never been able to take *Yarrella* actually alive, but, although my specimens were all dead, they were nevertheless quite fresh, having been just caught in the trawlers' nets.

The principal type of luminous organ consists of two components. As a rough generalization, one part is a bulb-shaped body lying within the muscle of the fish, and the other part is a funnel, or parabola-like body, which is in contact with the surface of the body and arranged on its sides.

The structure of the luminous organs of these two species of fishes is much the same as that of other luminous deep-sea fishes such as *Sternoptyx*, *Argyropelecus*, and *Maurolicus*. It consists of five components as shown in Figure 1. These five components are a luminous body, a reflector, a color filter, a lens, and a pigment membrane.

Luminous Body

When sectioned medially, it is seen to consist of a mass of cells radiating from a central point appearing not unlike the closely packed

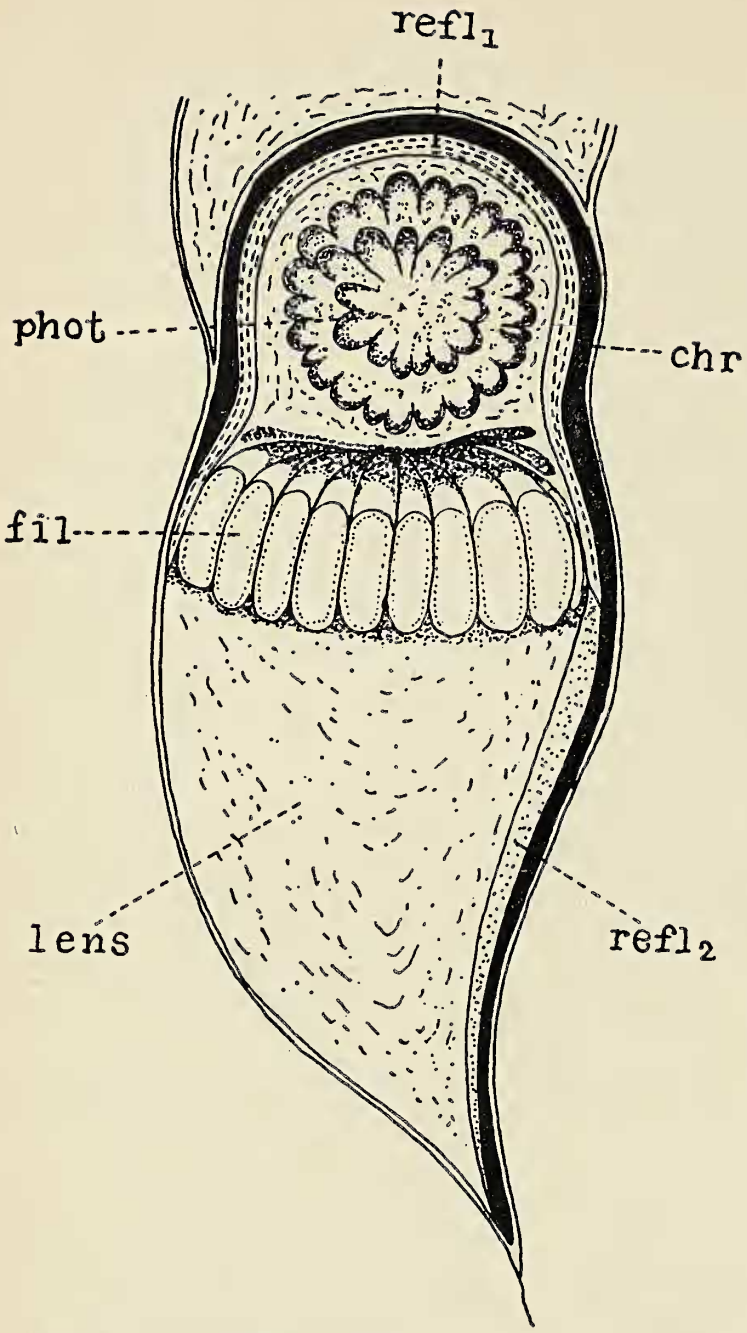

FIG. 1. Longitudinal section of the luminous organ of *Polyipnus stereope*. phot, Luminous body; $refl_1$, $refl_2$, reflectors; lens, lens; fil, color filter; chr, pigmented membrane.

seeds in a round seed capsule. When fresh material is cut with a thin knife, this organ appears to be milky blue and shows a bluish luminescence. This luminescence may continue for 4 to 5 hours after death. Sections cut from this organ stain well with haematoxylin.

Reflector

This consists of two parts. Part one (labeled $refl._1$ in Fig. 1) covers the inside of the luminous body and the filter. It is a silvery, opaque membrane. Part two ($refl._2$) covers the back of the lens and is composed of an arrangement of parallel fibers. Both parts reflect light extremely well.

Light Filter

Between the luminous body and the lens there is a transparent, single component which is beautifully colored. In *Polyipnus* and *Argyropelecus* it is a reddish violet. In *Yarrella* it is a ruby red. The color in some deep-sea luminous fishes is reproduced in "The Oceanic Fishes and Flat Fishes Collected in 1925–1927" by J. R. Norman (1930). *Argyropelecus* is shown as a reddish-violet color and *Bathytroctes rostratus* as orange. *Photichthys argentius* has a beautiful green color.

The tissues of this component are arranged in parallel, and its cells contain round nuclei and small granules. It may sometimes function as a lens, but it should be noted that both the curved upper and lower surfaces are parallel, the curves being in the same direction. Some investigators consider this component as the lens, but in my opinion it is simply a color filter.

These luminous organs *in situ*, when viewed ventrally by daylight, display a beautifully colored light in fresh specimens, but, if viewed laterally by daylight, this coloration can be seen localized only in this filter component and nowhere else.

I have examined living *Polyipnus stereope* in the dark, and have found the luminescence, as emitted, to be a greenish blue, whereas the color of the filter is violet. I was unable to obtain any living *Yarrella*, and am therefore unable to compare it with *Polyipnus*. The two species have filters of different color. One is violet and the other ruby red, and perhaps the color of their luminescence may be due to this difference in the color of their filters. However, owing to a lack of material for comparative purposes, I am unable to make any positive statement on this point.

Lens

The lens is a perfectly transparent, gelatin-like substance, and many investigators de-

scribe it simply as a mass of gelatinous substance without commenting on its shape. However, if fresh material is examined, the surface of the so-called simple mass of gelatin is convex, the body is swollen, and it has a definite shape. The only person to suggest that it might be a lens is Mangold (1910).

It is probable that most investigators have worked on preserved and dead material, and this may account for their failure to recognize it as a lens and to misunderstand its function. If the organ is put into alcohol or formalin, it contracts and becomes cloudy and shapeless, the sides shrink and become concave, and the coloring matter in the filter disappears. It is difficult to recognize the real function of the organ after such treatment.

Pigmented Membrane

This membrane covers the outside of the reflector. One of its functions is to assist the reflector, and another is to prevent light from being dissipated by entering the surrounding body muscle in which the organ lies.

Sometimes, the normally separate luminous organs are joined together to form a single luminous organ in the ventrothoracic region. Fine blood vessels enter through the reflector, ramifying in all directions within the luminous body and the filter. Nerves are also said to do the same, but I have not investigated this statement.

Unlike the Leiognathidae and other symbiotic luminous fishes which are able to control their display of luminescence by means of their chromatophores, *Polyipnus* and *Yarrella* are not provided with such structures. Nevertheless they can control it, but how they do so I am unable to say. Perhaps they are able to do it by means of their blood vessels or nerves.

These luminous organs are the closed type without any external openings and are unlike the open type possessed by the Gadidae (Kishitani, 1930), Macrouridae (Haneda, 1938), Monocentridae (Yasaki, 1928), Acropomatidae (Yasaki and Haneda, 1936), and Leiognathidae (Haneda, 1940), which possess external openings and are luminous by virtue of the luminous symbiotic bacteria within their open luminous organs.

I have been unable to find any bacteria, either luminous or non-luminous, in the organs of the *Yarrella* and *Polyipnus* fishes under discussion, in spite of an extensive search for them by the usual bacteriological methods. Luminous fishes with the closed type of luminous organs are true luminous fishes, and the luminosity which they display is the result of some product of the fishes' own creation and not the product of symbiotic bacteria living in the duct of the luminous organ of the fish.

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